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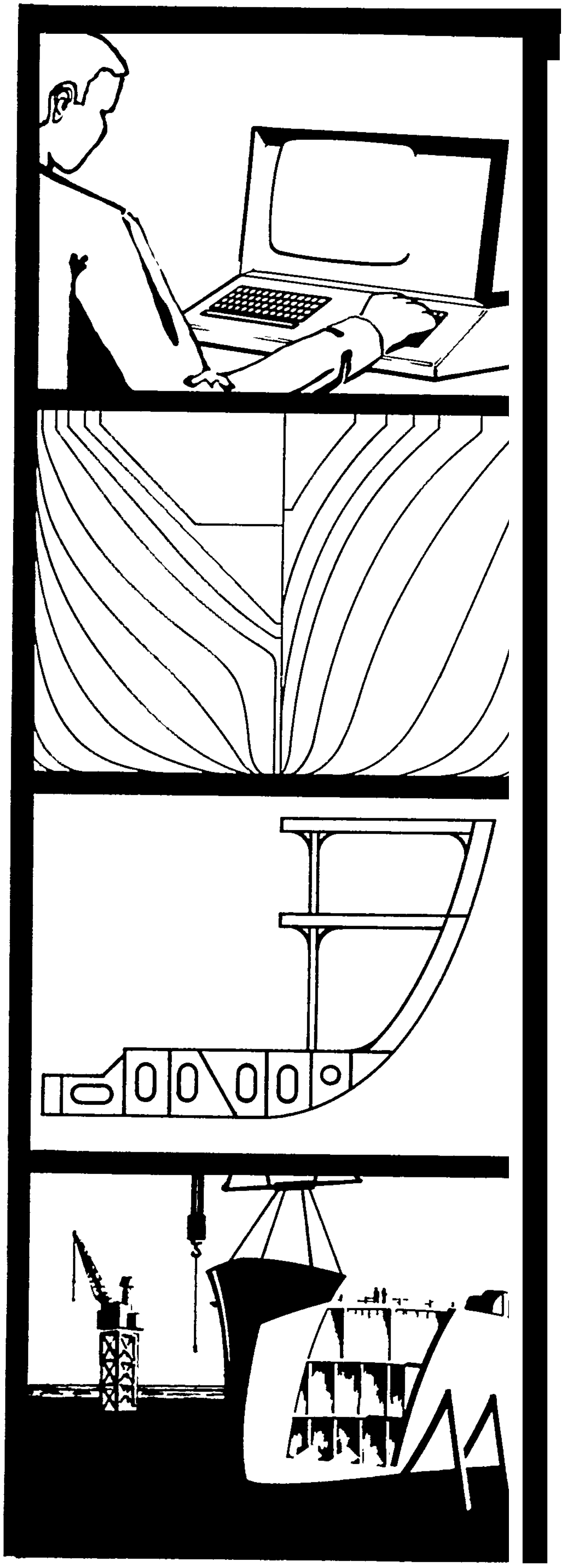

R ESEARCH
AND
E NGINEERING
FOR
A UTOMATION
AND
P RODUCTIVITY
IN
S HIPBUILDING

Proceedings of the REAPS Technical Symposium

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DISCLAIMER

DNC/CNC PLATE CUTTING AT BATH IRON WORKS

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Indianapolis, Indiana

Mr. Morgan is Manager of Engineering for the cutting machine manufacturing department. He has 10years experience in designing numerically controlled flame and plasma arc cutting machines. Mr. Morgan has a B.S. degree in electrical engineering from Rutgers University, New Jersey.

As the result of a prior commitment with the U.S. Coast Guard Reserves, Mr. Peck will not participate in the presentation of the subject paper this morning. Mr. S. C. Endris, N/C Project Superintendent at the Bath Iron Works Corporation, will deliver Mr. Peck's portion of the paper.

INTRODUCTION:

Bath Iron Works (BIW) is located in Bath, Maine, a community of several thousand people situated approximately 40 miles north of Portland, Maine.

(Slide #l & #2)

The principal business of BIW, presently and as in the past since the late 1800's, is Shipbuilding. The present workforce totals about 4,000 people. BIW, in recent months, built and delivered the OLIVER HAZARD PERRY (FFG-7), Lead Ship in the Navy's latest generation of Guided Missile Frigates.

(Slide #3)

Also, on May 24, 1978, BIW delivered the 720 foot Containership, MAUI, to Matson Navigation Company of San Francisco.

(Slide #4 & #5)

The present shipbuilding backlog at BIW includes the construction of eleven (11) guided missile frigates of the PERRY Class for the United States Navy and two (2) SEA WITCH Class Containerships for Farrell Lines.

Additionally, BIW-is actively involved in the ship repair and overhaul business and industrial fabrication work.

In order to present a complete overview of DNC/CNC cutting at BIW, the paper will concentrate on the following topics:

(VIEWGRAPH #1)

- ABSTRACT - Required System Capabilities (BIW)
- System Configuration (UCC)
- Job File Structure/Design (UCC)
- Actual Operation (BIW)
- **General Results** (BIW)

ABSTRACT - Required System Capabilities

The procurement and implementation of any major new system or process within the production environment, and I include design and engineering in this context, can potentially create much apprehension and confusion resulting in schedule disruptions. If. this is allowed to happen, acceptance of the new process by the users (employees) may be delayed. Accordingly, the full benefit of the system's or processes' capability may not be immediately realized thus reducing a company's initial return on investment.

Therefore, it was--the opinion of BIW that in order to ensure a smooth and effective system implementation BIW must define,in detail, the technical and scheduling requirements expected from the proposed DNC System.

(Viewgraph #2)

- Technically Define System's Requirements

and

- Establish Equipment Delivery, Installation and Activation Schedules

This developed into a tough assignment considering that BIW personnel had not acquired much knowledge of N/C systems and equipment at this time. Realizing the aforementioned, BIW elected to participate in the IITRI Managed AUTOKON Support Program.

Reviews of IITRI produced papers assisted in the technical definition of BIW'S desired DNC/CNC System. Viewgraph #3 represents BIW's overall DNC System requirements as presented to the prime contractor - Union Carbide and as in operation at BIW today.

(VIEWGRAPH #3)

Technical Requirements of BIW'S DNC/CNC System

- DNC - This stands for Direct "Numerical Control. BIW'S DNC System is one in which a central mini-computer provides data to a number of cutting machines and a plotter At each machine there is an item called a machine control unit (MCU) which accepts the data from the central mini-computer and translates it into machine commands. In Bath's system, the central computer provides the data in the same format as paper tape. In essence, the central computer is replacing the tape reader. The advantages are elimination of tape problems, mass storage of programs and increased control and speed.

- AUTOKON is the software system in use at BIW. The N/C equipment is compatible in all aspects with the AUTOKON System.

- The Host Computer is an UNIVAC 1108.

- A Remote Job Entry communications terminal is used to connect the N/C equipment center with the host computer.

- Key Entry and Verification by means of a disk storage **medium is standard practice at BIW for other systems.** Accordingly, a floppy disk system is used to facilitate standardization.

- Paper Tape is used as a back-up system only.

- Centralized Control of the Cutting Machines is essential at BIW in order to achieve the required material thruput. Accordingly, personnel in the Fabrication Control Center direct the raw-material flow to the desired cutting machine and, by utilizing DNC, forward the appropriate cutting data to the correct, machine.

- Multiple Task Operations of the communication terminals is utilized to support all of the possible operations of the equipment within a realistid time frame.

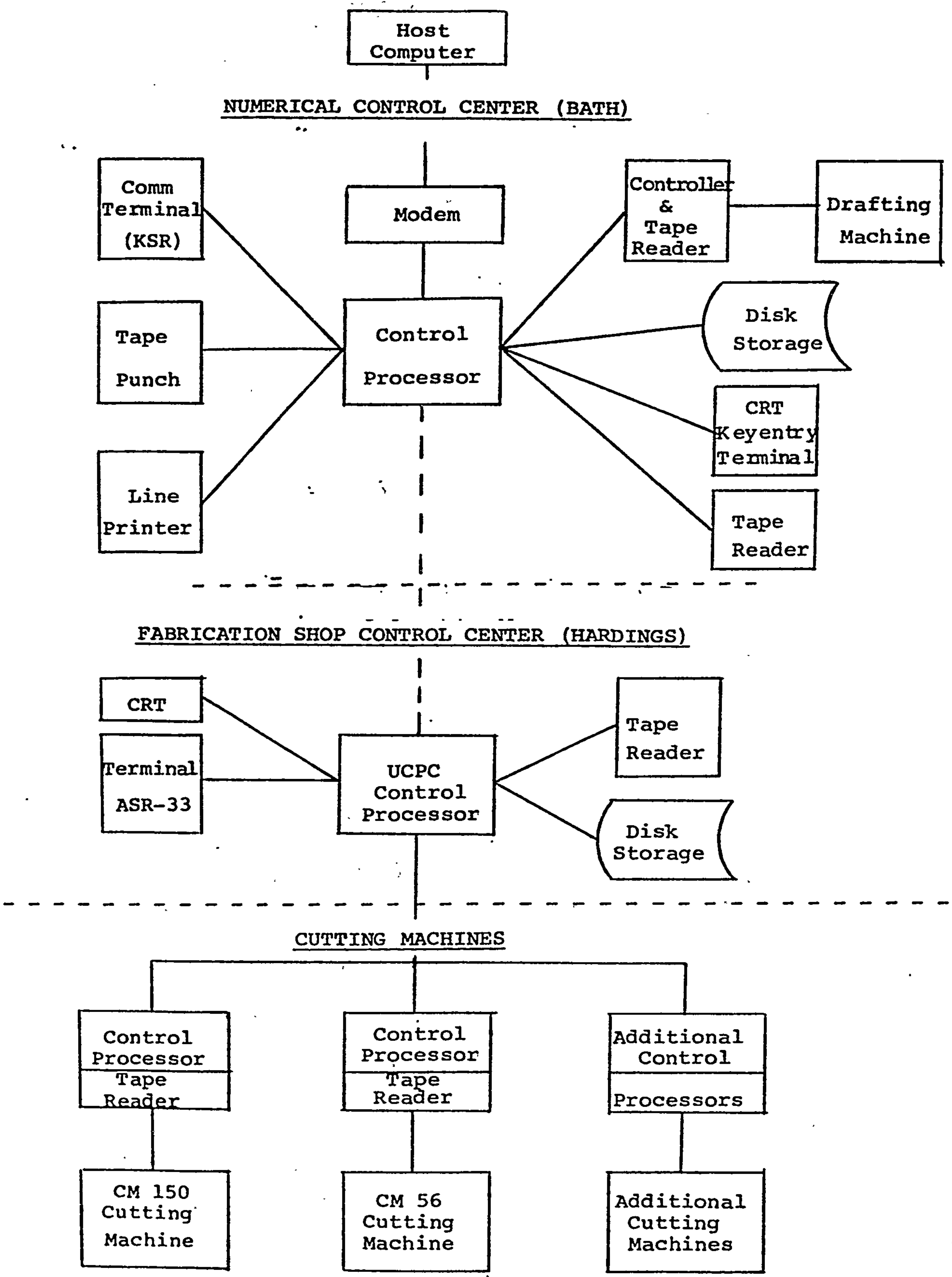
- Equipment Reliability is essential to tight production schedules.

As nreviously stated, the information and system requirements contained in Viewgraph #3 formed a major portion of the purchase agreement with Union Carbide and basically established the overall system configuration. Using this information, R. M. Morgan, Manager of Engineering at Union Carbides Advanced Systems Division, developed the hardware and software configuration to accomplish Bath’s requirements.

SYSTEM CONFIGURATION (Viewgraph 4 & 4a)

The Distributed Numerical Control (DNC), Computer Numerical Control (CNC) System at the Bath-Harding facilities was designed as a Remote Job Entry (RJE) terminal, real time Disk Operating System (DOS), Plotter Verification Center and direct control of the cutting machine numerical controls (DNC) in a completely tapeless and cardless operation. The real time operating system has been designed to allocate the various resources of the computer system in response to request from the connected peripheral hardware in a large, batch-oriented N/C system such as Autokon or Spades. The heart of this is the terminal computer and the Disk Operating System (DOS) for controlling the CRT, line printer, storage devices, modems and the communicated terminal used by the operator. The operating system (DOS) has been written to emulate a card reader system but without the need for readers and punches (backup mode). The operator loads the disk via his terminal-device and the disk information is sent directly to the Univac computer when the two computers are connected. (called send file). Nhen the Univac computer completes its calculations the programs are sent to the Bath terminal (called receive file) in the form of a print and punch files. The print file information is directly printed on the Data 100 high speed line printer, the punch files are stored on the disk designated for receiving.

BIW'S DNC/CNC SYSTEM CONFIGURATION VIEWGRAPH #4



These output punch files that are stored on the receive disk are then checked on the plotter and when correct and-ready for cutting, -organized and stored on two diskettes - one as a master and the other for sending to the burning machines.

The second diskette is logged out by the Production Control Department, attached to the instruction sheets, plots. etc., and as a package, sent to the Harding Control Center. The Fabrication Control Center operator (controlling the cutting machines and plate handling system) loads the disk electronically to the burning machine when requested by the machine operator. The reason for this Direct Numerical Control (DNC) System is to automate the distributing and controlling of machine programs generated at the Bath Terminal. This system completely eliminates the major,weakness of a numerical control - paper tapes, tapepunches, tape readers and the wasted time to control and generate. When all programs on a particular disk has been cut, the disk is returned to Production Control, logged back in and stored with the master. This return procedure reduces the chances of later accidential cutting and for future use.

The Harding System has the capacity to communicate directly with four cutting machines and if needed, direct batch communication with the Bath Terminal. At present this final loop will not be closed, as Bath with the present system, has better control of where things are, what is cut and what programs are returned. With the present system all information is received as a complete packet when needed from Production Control. A daily messenger now carries daily mail, drawings, etc. so why not include the diskette with the drawings. For this reason, the cost of modems, Bell Lines and computer input-output (I/0) is not justified. The present method of operation also reduces the possibility of conmmunications error over the Bath Harding Network.

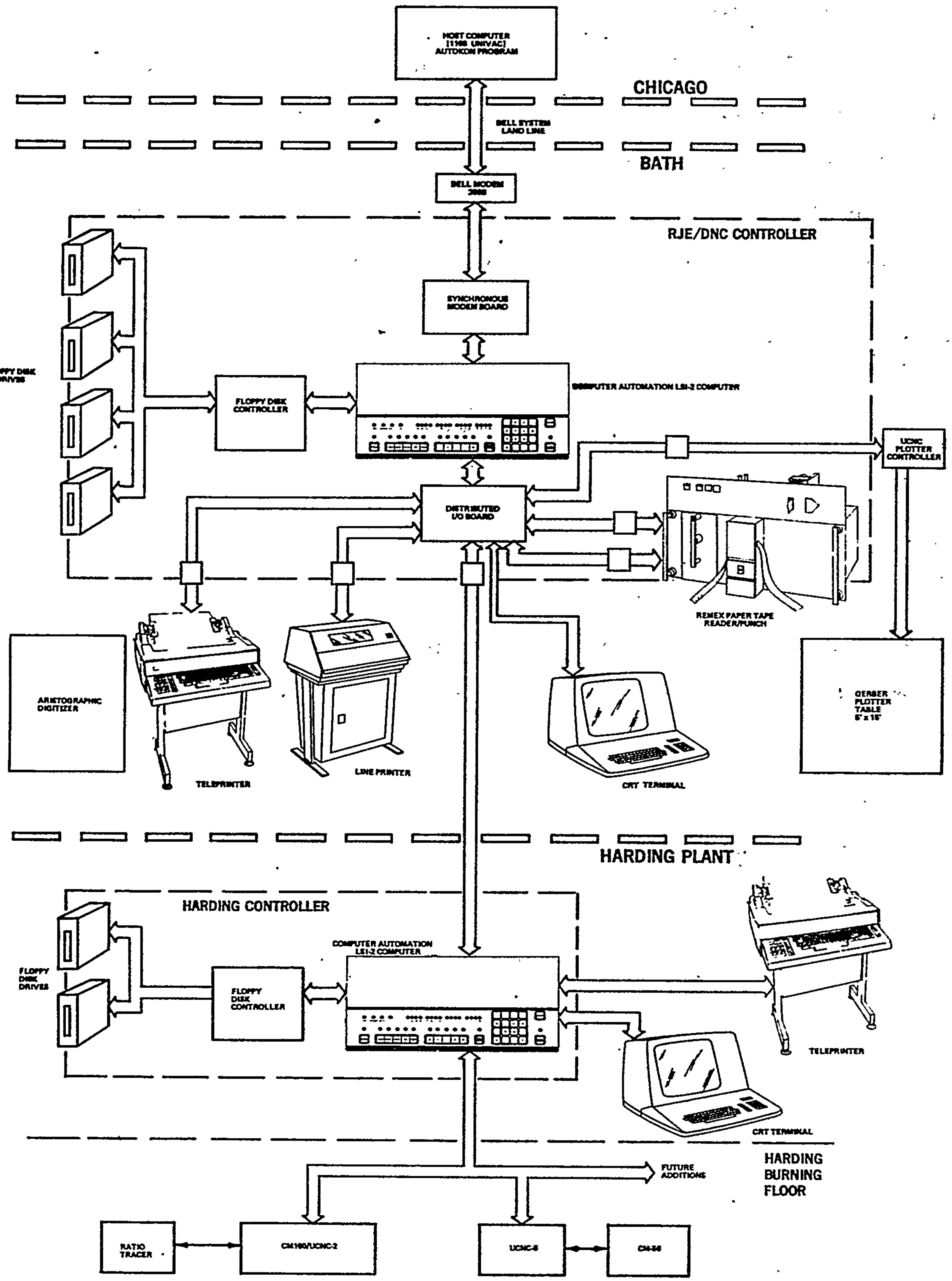
HARDWARE

Viewgraph 4A depicts the configuration for the Bath Terminal System and the Harding Burning Facility. The system processors are standard 16 bit mini-computer systems using 32K of memory. A total of 8 I/0 slots are provided for peripherial units, and a Direct Memory Access (DMA) channel interface for high speed block data transfers to the disk drives.

The synchronous communication controller/interface provides the data Link via a standard Bell (like 208B) modem to phone lines for accessing the central Univac 1108 Host computer. It is RS-232 compatible and can accommodate synchronous data transmission at rates of up to 4800 Baud.

The system console may be either the standard 24X80 CRT Keyboard display or the Centronics 701 teleprinter, depending on which is selected by the operator. Its primary function is in entering and receiving system-related information (commands, data, local programming, etc.) and as the operator console for RJE jobs for those RJE protocols which require the presence of such a device.

The 132 column Data 100 impact type line printer rated at 300 Lines Per Minute (LPM) is compatible with the nomjnal data rate of 4800 Baud. That is, at this data rate the device neither forces the central site computer to wait for them long periods of time nor forces the terminals' system processor to wait for the communications line to finish handling data for them. Functionally, the 75 character/second Paper Tape Punch is used to punch out the verified N/C tapes, when required, to run the numerically controlled flame cutter. Prior to transmitting this tape to the burning ship, the tape will typically be read back into the punch file (stored on the disk) from which it was produced to verify its accuracy. The PTR & PTP are used as a backup system at Bath.


HOST COMPUTER
AUTOKON PROGRAM
CHICAGO
BELL SYSTEM
LAND LINE
BATH
RJE/DNC CONTROLLER
SYNCHRONOUS
MODEM BOARD
FLOPPY DISK
DRIVES
FLOPPY DISK
CONTROLLER
DISTRIBUTED
I/O BOARD
UCNC
PLOTTER
CONTROLLER
REMEX PAPER TAPE
READER/PUNCH
ARISTOGRAPHIC
DIGITIZER
TELEPRINTER
LINE PRINTER
CRT TERMINAL
GERBER
PLOTTER
TABLE
HARDING PLANT
HARDING CONTROLLER
COMPUTER AUTOMATION
LSI-2 COMPUTER
FLOPPY
DISK
DRIVES
FLOPPY
DISK
CONTROLLER
TELEPRINTER
CRT TERMINAL
HARDING
BURNING
FLOOR
FUTURE
ADDITIONS
RATIO
TRACER
CM100/UCNC-2
UCNC-8
CM-58

The Shugart disk drives serves two essential purposes in the terminal system. First, since a real time multi tasking operating system is being used, the drive serves--as an extension to the terminal memory for task,swapping; Secondly, it serves as a repository for both system and user programs and data. Four removable disk units, as shown in Figure 4a can store-approximately 1,000,000 characters of punch file information (approx. 8,000 feet of tape).

JOB FILE STRUCTURE/DESIGN

Floppy Disk System

(Refer to Viewgraph #5).

The floppy disk system has proven to be very easy to work with and inexpensive storage. 'Both fixed disk and floppy disk were studied in the original design. The floppy disk being chosen for its price and flexibility. The terminal system contains four disk drives which are normally assigned as follows.

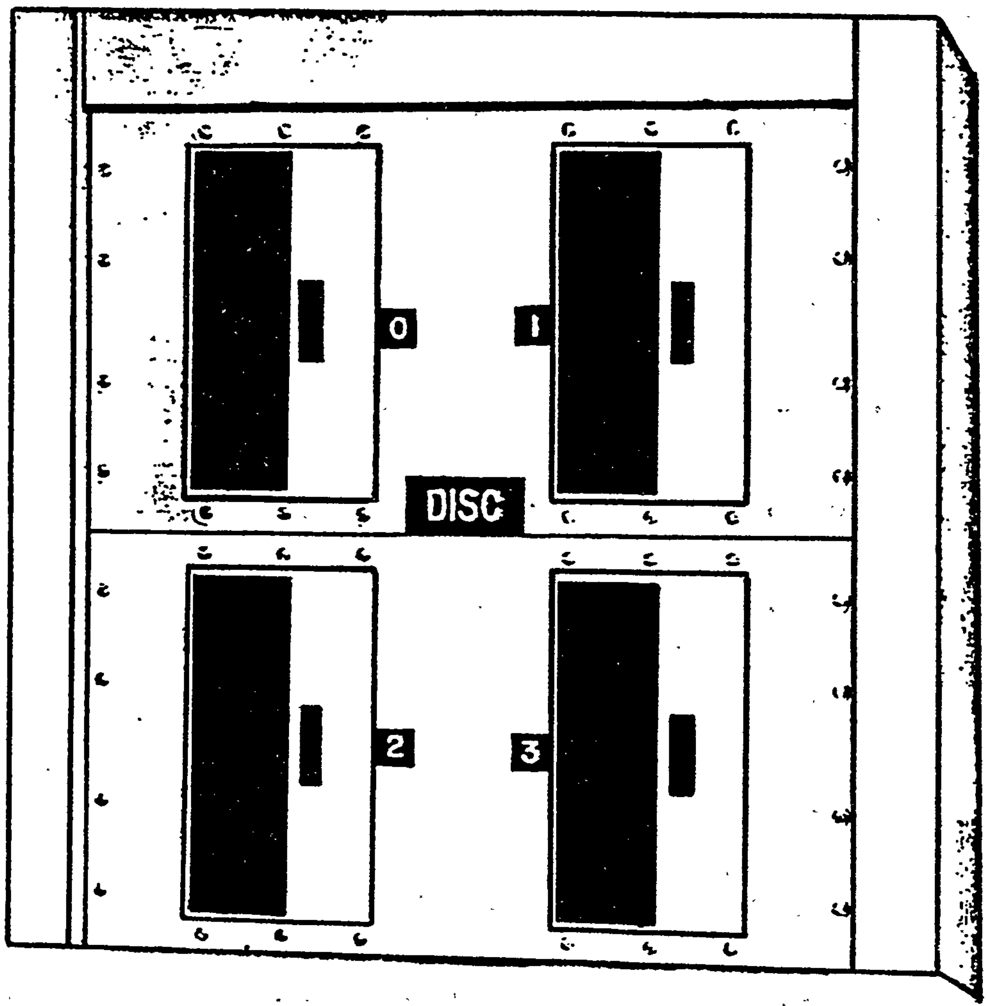
Drive Ø - JCL Diskette

Drive 1 - Manuscripts

Drive 2 - Autokon output (receive file).

Drive 3 - Plotter Data

FLOPPY DISK SYSTEM



The system has been designed to allow multiple operations at the same time. This allows key entry and plotting to occur concurrently. Segregating data on specific drives and stating the disk drive in the read write or plot command provides a very efficient operating-system with little interruption to slow down either operation

BIW'S cutting machine is located in the Fabrication Shop (Hardings) approximately four miles from the shipyard and the loft area (Bath) where the Numerical Control Center is located. The modular construction methods employed at Bath Iron Works adapt very well to the floppy disk concept. A diskette is prepared with the cutting data for one construction unit. A copy of the diskette is prepared with one going to the cutting machine area and the other being retained in the Numerical Control Center. This enables the cutting machine area, to operate independent of the Numerical Control Center.

FIoppy Disk File Structure

(Refer to Viewgraph #6)

The floppy disk file structure consists of files and a further breakdown of subfiles within files. This structure has worked very well in relation to modular construction. Many parts comprising a unit can be associated with the construction unit very easily. Due to the way the directory is set up, a maximum of 47 files may be placed on one diskette. Utilizing the subfile structure which has no limitation, maximum utilization of each diskette can be accomplished. The only restriction to the size of file/subfile structure is the size of the buffer used for file reading and writing. In order to modify a file, the entire file must be read into the computer memory buffer which has a limitation of about 14,000 characters. Therefore, by keeping track of the number of characters in a file as shown by taking a catalog of a file, maximum diskette space is utilized as shown by the directory of disk drive 2 where 147 out of a possible 219 sectors are occupied.

VIEWGRAPH #6

FLOPPY DISK FILE STRUCTURE

I. FILENAME
    II. SUBFILENAME

- Directory gives a listing of all files
- Directory gives the number of sectors occupied by a file
- Catalog gives a listing of all subfiles within a specific file
- Catalog gives the number of characters within each subfile

```
DIR 2

DIRECTORY DRIVE F2   DISK 1013
NEFB11        0 0 0 0   1978/5/12    12
NEFB12        0 0 0 0   1978/3/8     12
NEFB13        0 0 0 0   1978/3/9     10
NEFB14        0 0 0 0   1978/3/22    11
NEFB15        0 0 0 0   1978/4/19    2
NEFB16        0 0 0 0   1978/5/3     9
NEFB17        0 0 0 0   1978/5/4     10
NEFB18        0 0 0 0   1978/5/22    3
NEFB19        0 0 0 0   1978/5/19    10
NEFB20        0 0 0 0   1978/5/19    8
NEFB21        0 0 0 0   1978/5/30    11
NEFB22        0 0 0 0   1978/5/31    9
NEFB23        0 0 0 0   1978/5/31    9
NEFB24        0 0 0 0   1978/6/1     9
NEFB25        0 0 0 0   1978/6/1     9
NEFB26        0 0 0 0   1978/6/1     10
NEFB27        0 0 0 0   1978/6/2     3

17 ENTRIES.  SPACE USED 147 OF 219
```

Number sectors occupied by file

```
0:CAT 2,NEFB15

NEFB15
                          76
#NC-1154-05#              161
#NC-914#                  404
#NC-195#                  647
#NC-335#                  166
```

Number characters per subfile

File Name Structure

File names for manuscripts, send files, receive files, and job control language have been designed for easy access and traceability of documents.

(Refer to Viewgraph #7)

Manuscripts or Autokon programs begin with a two character data-base designation followed by a four character structural unit designation. Then there is a seven digit piece number followed by a two digit programmer identification number. The piece number and programmer identification number appear on the programmers original handwritten manuscript, it appears on the computer generated output manuscript and is automatically generated by the Autokon System as a label for the plotted part. This enables the Numerical Control Center to keep all the documents for a given part in one package.

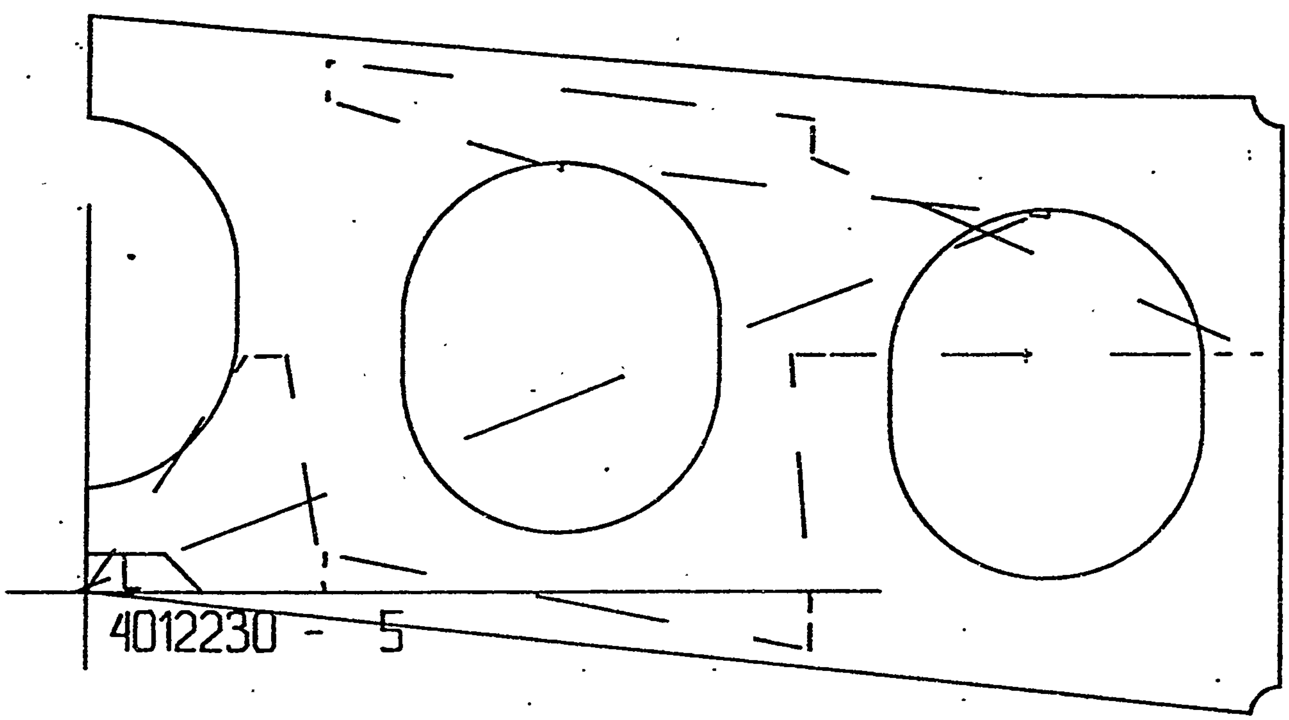
(Refer to viewgraph #7A)

MANUSRCIPT (PROGRAM) NAME STRUCTURE

XX	XXXX	XXXXXXX	XX
DATABASE DESIGNATION	SHIP STRUCTURAL UNIT DESIGNATION	PIECE NUMBER	PROGRAMMER IDENTIFICATION

EXAMPLE: $\underbrace{\text{FBØ2Ø1}}_{\text{FILE}}\ \underbrace{\text{2Ø172Ø1 Ø6}}_{\text{SUBFILE}}$

Viewgraph #7A



(Refer to Viewgraph #8)

Send files are created which tell the system what information should be sent to the Autokon System for execution. The file names consist of a two character send file designator; a four digit date, a daily sequential number, and a two character Autokon designation. The send file designator is SF or SA signifying a send file for the forebody database or aftbody database.

(Refer to viewgraph #9)

Receive files are named in a similar fashion to send files and enable the output data to be associated with the data sent. A two character receive file designation, RF for receive forebody database and RA for receive aftbody database. A four digit date, a daily sequential number and an Autokon module designation.

VIEWGRAPH #8

SEND FILE (JOB STREAM) NAME STRUCTURE

XX	XXXX	X	XX
SEND FILE DESIGNATION	DATE (MMDD)	DAILY SEQUENTIAL NUMBER	AUTOKON MODULE DESIGNATION

VIEWGRAPH #9

RECEIVE FILE (AUTOKON OUTPUT) NAME STRUCTURE

XX	XXXX	X	XX
RECEIVE FILE DESIGNATION	DATE (MMDD)	DAILY SEQUENTIAL NUMBER	AUTOKON MODULE DESIGNATION

EXAMPLE: $\underbrace{\text{RF}}_{\text{Receive Forebody}}$ Ø627 1 $\underbrace{\text{AL}}_{\text{ALKON}}$

JCL File Structure

(Refer to Viewgraph #lO)

Job control language consists of the instructions necessary to execute the Autokon System on a Univac 1108 computer. Job control language has been prepared and keyentered for all Autokon modules currently in use by Bath Iron Works. Because the control language is stored on a floppy disk, file names had to be generated in-order to retrieve the control statements as needed. Names were generated which would enable the Numerical Control Center operators to select the proper control statements with minimal information from the programmers. The names consist of a three character designation for job control language, a one character heading or ending designation, a two character database designation, a two character Autokon module designation and a one character priority designator. It can be seen that by knowing which database to access and which Autokon module is to be utilized, the correct job control language can be selected.

JOB CONTROL LANGUAGE (JCL)

XXX	X	XX	XX	X
CONTROL LANGUAGE DESIGNATOR	HEADING ENDING DESIGNATOR	DATABASE DESIGNATION	AUTOKON MODULE DESIGNATION	PRIORITY

Aft Body

EXAMPLE: JCL H AB AL Z

ALKON

Heading

RJE Structure

(Refer to Viewgraph #11)

The Remote Job Entry or RJE command directs and will seek and send the file or files to the host computer for processing. It also directs which file is to be used as a data receive file.

(Refer to viewgraph #12)

In the following example, a send file has been created which consists of heading JCL, two manuscripts, and the job termination or ending JCL. The file name created as the send file is SF0627 lAL and it consists of four subfiles:

1. JCLHFBAL
2. FB0201 201720l-06
3. FB020 2011414-12
4. JCLEBBAL

VIEWGRAPH #11

REMOTE JOB ENTRY COMMAND

RJE RF ;SF1 ;SF2

Send File 1

Send File 2

Receive File (Autokon output)

EXAMPLE: RJE RF0627 IAL ;SF0627 lAL

VIEWGRAPH #12

SEND FILE STRUCTURE

SFØ627 1AL (filename)
JCLHFBAL
FBØ2Ø1 2Ø172Ø1-Ø6
FBØ2Ø1 2Ø11414-12 **(subfile names)**
JCLEBBAL

Both Bodies (common to both data bases)

Ending

(Refer to Viewgraph #l3)

The JCLHFBAL is the job control language which directs the host computer to execute the proper Autokon module with the correck database. FB0201 2017201-06 and FB020l 2011414-12 are the manuscripts which are to be executed. JCLEBBAL is the job control language which terminates this particular run.

VIEWGRAPH #13

TYPICAL- JOB STREAM

```
@RUN BIW000,,CBJ000/GJ2UG6,15,100/1000
@COL FLD
@HDG  xxx  FFGFOLLOWSHIP FOREBODY ALKON  xxx
@ASG,AX ABSxVERC
@USE A.,ABSxVERC
@ASG,AX BIWxFBDATA
@USE 12.,BIWxFBDATA
@ASG,T  11.,F/100//900
@XQT  A.ALKON/BATH
FFGFOLL  FB
```

JCLHFBAL
(job control language)

```
? COMM(#2017201-06#FWDxxx   JOB2017B    FACE PLT  1-OFF CL EBW)
PERML'
ON(KWC)
SPT
MARK(21+61+O)        MARK(3F+lI+90)     MARK(7F+1I+90)
MARK(llF+lI+t+90)    MARK(15F+1I+90)    MARK(17F+lI+90)
MARK(19F+1I+90)      MARK(23F+1I+90)    MARK(27F+1I+90)
MARK:(28F81+.61+0)   MARK(27F+9I+90)    MARK(23F+9I+90)
MARK(19F+9I+9o)      MARK(17F+9I+90)    MARK(15F+91+90)
MARK(llF+91+90)      MARK(7F+9I+90)     MARK{3F+9I+90)
RAP:EPT'
SL:EPT(29F+0)
SL:EPT(29F+1F)
SL:EFT(O+lF)
SL:EPT'
END  LGEO'
FIN  BIWM(2O17201+06)
```

FB0201 2017201-06
(manuscript)

```
? COMM(#2011414-12#FWEXXX  2011A  1  OFF  CL  JBB)
PLSURF50(5F5I+0+5F51+9F21+0+9F21+2011414+12)
```

FBØ2Ø1 2O11414-12
(manuscript)

```
&
@FIN
@@
```

JCLEBBAL
(job control language)

Supplementary Software

Bath Iron works functions without the use of paper tape or punched cards and as such software was developed to assist in operating without either of the above mentioned mediums. Editor software was developed for keyentry and verification. Commands available while in the edit mode are as follow:

{Refer to Viewgraph #14)

1. Delete
2. String Replace
3. File Read
4. File Write
5. Insert
6. Print
7. Verify

In addition to keyentry, verification, and editing of data, it is necessary to be able to manipulate files. File manipulation software which has been developed is commanded as follows:

EDITOR COMMANDS

Delete
String Replace
File Read
File Write
Insert
Print
Verify

FILE MANIPULATION COMMANDS

Catalog
Change
copy
Delete
Directory
List
Plot
Punch
Tape Duplication

1. Catalog
2. Change
3. copy
4. Delete
5. Directory
6. List
7. Plot
8. Punch
9. Tape Duplication

The PLOT command is used to direct the transfer of data to be plotted from disk storage on the RJE terminal to the plotter controller. This can be done for an entire file or any subfile within a file. If an entire file is plotted, several plots can be done consecutively with only repositioning of the plotter being necessary between plots.

FILE MANIPULATION

COMMANDS	SYNTAX	
CAT	CAT_/$xx_Ø,xxxx Listing Device (optional) · File Name	Catalog of a specific file - lists to CRT or optional device: subfile names and number of characters.
CHG	CHG_Ø, xxxx>Ø, xxxx Old File Name · New File Name	Change file name only - requests confirmation: enter 'Y' or cancel by carriage return.
COPY	COPY_Ø, xxxx>!Ø, xxxx File To Be Copied · No Entry = New File, + = Add, ! = Replace · Destination File	Copy one file to another - may be added to or replace destination file; either file ident. may be a peripheral device.
DATE	DATE_xxxx/xx/xx Year · Month · Day	Type DATE & carriage return to check, must be updated daily. To Sort by creation date: type DIR T.
DEL	DEL_Ø,xxxx File Name	Delete the file - requests confirmation: enter "Y" or cancel by carriage return.
DIR	DIR_/$xx_Ø Listing Device (optional) · Drive Ident.	Directory of a specific disk - if no disk is identified entire scratchpool directory will be listed.
DNC x	DNC x_Ø,xxxx Machine To Be Directed · File Name	Opens designated file to designated machine - at the completion of, or to terminate an operation Type: DNC x and carriage return to close file.
FORMAT	FORMAT_Ø,xxxx Drive Ident. · Disk Ident	Format a fresh disk and assign a disk ident. - ID may be any number from 1 to 32000.
LIST	LIST_/$xx_Ø,xxxx#xxx# Listing Device (optional) · File Name · Subfile Name (optional)	Lists the contents of a file with line numbers added by the system - may list to peripheral device.
PLOT	PLOT_Ø,xxxx File Name	Opens designated file to the plotter controller - at the completion of plot, the file must be closed by typing: PLOT and carriage return.
PUNCH	PUNCH_/BURN *xxxx*Ø,xxxx Burning Data Only (Optional) · Operator Readable Title (optional) · File Name	Punch Tape for plotter or burning machine use - titles (operator readable) may be added to leader.
SDRV	SDRV_Ø,1,2,3 Drive Ident. (any or all)	Assign specific drives to the scratchpool - existing scratchpool may be listed by SDRV and carriage return.
TDUP	TDUP	Connects Tape Punch to Tape Reader for duplicating tape - execution begins with carriage return.

REMOTE JOB ENTRY

COMMANDS	SYNTAX	
TEST	TEST_:xx; xxxx; xxxx Number of File Lines To List · Command File No. 1 · Command File No. 2	Used to confirm RJE file order and content - specified number of lines from each file is listed for review.
RJE	RJE_/$xx_xxx; xxx; xxx Print Data Device · Punch Data Device · Command Filename · Command Filename	Used to initiate a RJE transaction - terminal will respond with: ESTABLISH PHONE LINK. Call-up host and press data button.

OPERATIONAL MODE

The Bath Iron Works Numerical Control Center functions as a service organization to the Mold Loft and the Cutting Machine area. Manuscripts are submitted to the Numerical Control Center where they are processed in accordance with a unit schedule established by the Mold Loft. Manuscripts are keyentered or edited as the case may be and processed through the correct Autokon Module. When the manuscripts have been executed through the Autokon System and the output data plotted, all the information for that-manuscript is returned to the N/C programmers for verification. When parts verification, nesting and nest verification have been completed, the N/C Center prepares a floppy disk with all the data necessary for a given construction unit.

(Refer to Viewgraph #15)

Then a mylar plot is prepared which is sent to the Mold Loft where additional information is added. A copy cf the diskette is prepared and retained in the N/C Center and the other version is delivered

VIEWGRAPH #15

DIR 3

```
DIRECTORY  DRIVE  F3   Disk  1058
ENEF201      0 0 0 0   1978/6/2     11
BNEF201A     0 0 0 0   1978/6/2     11
BNEF201B     0 0 0 0   1978/6/2     11
BNEF201C     0 0 0 0   1978/6/2     11
BNEF201D     0o  0 0   1978/6/7     11
BNEF201E      000 0    1978/6/7     9
SHFB201      0 0 0 0   1978/4/27    11
SHFB201A     0 0 0 0   1978/4/27    11

8 ENTRIES.  SFACE USED 86 OF 219
```

```
O:CAT  3,BNEF201

BNEF201
                                   23
#BIW000  NC-1211-12  #             465
#BIW000  NC-1212-12  #             324
#BIW000  NC-1213-12  #             1261
#BIW000  NC-826-12  #              825
#BIW000  NC-166-12  #              970
#BIWOOO  NC-1219-11  #             1906
#BIW000  NC-212-11                 2482
#BIW000  NC-121O-12  #             826
#BIW000  NC-274-03 #               2601
```

```
O:CAT  3,BNEF201A

BNEF201A
                                   22
#BIW000  NC-232-06 #               7951
#BIW000  NC-304-07 #               4401
```

```
O:CAT  3,BNEF20l

BNEF201B
                                   22
#BIW000  NC-193-03 #               607
#BIW000  NC-252-03 #               3560
#BIW000  NC-1225-06                1402
#BIWOOO  NC-824-06  #              2770
#BIWOOO  NC-202--06  #             3899
```

to Mold Loft personnel for forwarding to the Cutting Machine Area along with a copy of the Mylar plot.

Upon completion of the cutting of the information contained on a given diskette, the diskette is returned to the Mold Loft for retention until that unit is again scheduled for cutting. With the Mold Loft acting as the retention center, it ensures that any changes occurring prior to cutting a unit for another hull will be incorporated onto that unit's diskette.

General Results

The DNC System installed at Bath Iron Works has been functioning in a production environment since October of 1977. The results have been better than expected as evident by the following:

- Relofting Output

  As of June 1978, BIW’S Mold Loft had relofted eleven (11) of the sixteen (16) major construction units on the FFG ships.

In addition, several miscellaneous units have also been relofted.

Ten (10) recently trained programmers, formally 1/10 scale loftsman, have accomplished this relofting effort.

- <u>production Output - Cutting Machine</u>

The new N/C cutting machine with plasma arc capability is now dedicated to producing the cut parts for the Navy FFG program. The new N/C plasma machine will cut at a rate of 175 ipm as compared to the previous telerex rate of 15-20 ipm. It should also be noted that as a result of plasma non-ferrous material is being processed through this machine in lieu of shearing or sawing.

l <u>Equipment Reliability</u>

- <u>Cutting Machine</u> - the amount of lost production time since December, 1977, as a result of cutting machine equipment failure or communications problems between the Hardings' Control Center and the cutting machine has been minimal. BIW did chose to cut with paper tape in lieu of directly from floppy disk on five (5) occasions. The use of paper tape was required as a result of initial communications problems between the control center and the cutting machine controller. This occurred when the amount of data to be transferred exceeded the cutting machine computer buffer

  Union Carbide has just recently revised the communications software to resolve this problem.

- Bath Control Center Equipment

This center has been functioning since October 1977 entirely in the DNC mode. The paper tape capability of this center has only been used to produce and verify the five aforementioned tapes and to test the System's paper tape capability.

In essence, BIW is extremely pleased with our present DNC system. BIW’S decision to use paper tape as only a back-up system has proven to be a good one!

Additional copies of this report can be obtained from the National Shipbuilding Research and Documentation Center:

http://www.nsnet.com/docctr/

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